

55V, 300W Source/Sink Hybrid Step-Down Non-Isolated μ Module Bus Converter

General Description

The EVAL-LTM4654-AZ evaluation board features the [LTM[®]4654](#), a high-efficiency, high-power-density, bi-directional hybrid power μ Module[®] (micromodule) converter. The EVAL-LTM4654-AZ can deliver 12V at 25A with an input voltage range of 36V to 55V (up to 57V during transients).

The LTM4654 uses an architecture that merges soft switching in a Switched capacitor (SC) topology with a traditional step-down converter to provide superior efficiency compared to traditional switching architectures. The LTM4654 offers a high-efficiency, high-density, and cost-effective solution for non-isolated intermediate bus applications for power distribution, datacom centers, and telecom applications.

The LTM4654's current mode control architecture can parallel multiple LTM4654 modules to operate in a multiphase configuration with excellent current sharing and low output voltage ripple to enable much higher power applications. Low electromagnetic interference (EMI) emissions and reduced Metal-oxide-semiconductor field-effect transistor (MOSFET) stress can be achieved with the soft switching front end.

The LTM4654 design eliminates the inrush current typically associated with SC circuits by pre-balancing the capacitors on startup.

The LTM4654 monitors the system voltage, current, and temperature faults. It stops switching and pulls the FAULT pin low when a fault condition occurs. An onboard timer sets the appropriate restart or retry times.

The LTM4654 data sheet must be used in conjunction with this evaluation board user guide.

Features and Benefits

- $\pm 3\%$ Output Voltage Accuracy Over Temperature
- Clock Output for a Multiphase Operation
- Power Good Output Signal
- Short-Circuit Protection
- Monotonic Output Voltage Startup
- Optional External Reference
- Undervoltage Lockout (UVLO)
- Internal Charge Balance Circuitry

EVAL-LTM4654-AZ Files

FILE	DESCRIPTION
EVAL-LTM4654-AZ	Design files.

[Ordering Information](#) appears at end of this user guide.

Evaluation Board Photo

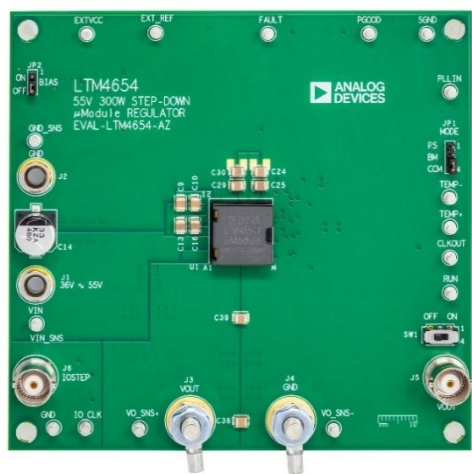


Figure 1. EVAL-LTM4654-AZ Evaluation Board (Part Marking Is Laser Mark)

Performance Summary

Specifications are at $T_A = 25^\circ\text{C}$.

PARAMETER	CONDITION	MIN	TYP	MAX	VALUE
Input voltage range		36		55	V
Output voltage, V_{OUT}	$V_{IN} = 36\text{V to } 55\text{V}$, $I_{OUT} = 0\text{A to } 25\text{A}$			12	V
Maximum output current, I_{OUT}	$V_{IN} = 36\text{V to } 55\text{V}$, $V_{OUT} = 12\text{V}$			25	A
Typical efficiency	$V_{IN} = 48\text{V}$, $V_{OUT} = 12\text{V}$, $I_{OUT} = 25\text{A}$		96.7		%
Peak efficiency	$V_{IN} = 48\text{V}$, $V_{OUT} = 12\text{V}$		96.9		%
Default switching frequency			430		kHz

Quick Start

Required Equipment

- Power Supply
- Digital Voltmeters (DVMs)
- Load

Quick Start Procedure

The EVAL-LTM4654-AZ evaluation board is easy to set up to evaluate the performance of the LTM4654. See [Figure 2](#) for proper measurement equipment setup and use the following procedure.

1. With the power off, connect the input power supply to VIN (36V to 55V) and GND (input return).
2. Connect the output load between VOUT and GND (initial load: no load). See [Figure 2](#) for more details.
3. Connect the Digital voltmeters (DVMs) to the input and output.
4. Check the default jumper/switch position: SW1 (RUN): OFF.
5. Turn on the input power supply and adjust the voltage to 48V.

NOTE: Ensure that the input voltage does not exceed 55V.

6. Set the RUN switch in the ON position.
7. Check for proper output voltages from VO_SNS+ to VO_SNS-.
8. Once the proper output voltage is established, adjust the load within the operating range and measure the efficiency, output ripple voltage, and other parameters.
9. After completing all tests, adjust the load to 0A, and power off the input power supply.

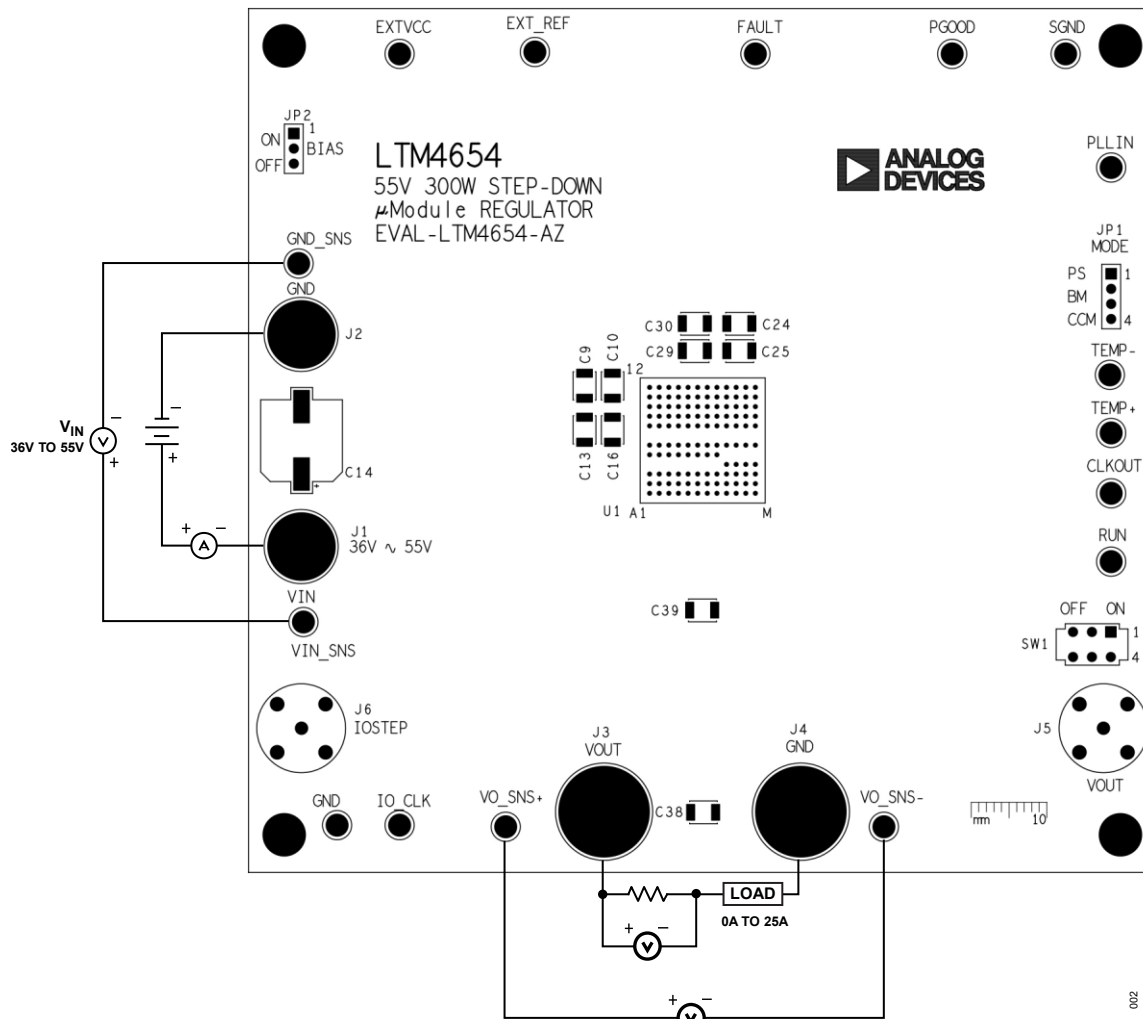


Figure 2. Proper Measurement Equipment Setup

Important Notes

Do not use the long ground lead on the oscilloscope probe when measuring the output or input voltage ripple. See [Figure 3](#) for the proper scope probe technique. Short, stiff leads need to be soldered to the (+) and (-) terminals of an output capacitor. The probe's ground ring needs to touch the (-) lead, and the probe tip needs to touch the (+) lead.

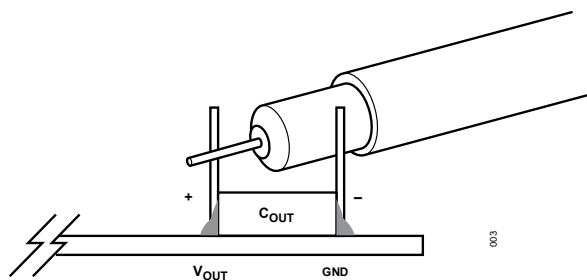


Figure 3. Measuring Output Voltage Ripple

When performing the load step test with the onboard dynamic load circuit, ensure that the load step-up pulse duty cycle does not exceed 2% and the pulse duration is less than 500μs so that the temperature of the MOSFETs, Q11, and Q12,

in the dynamic load circuit stays in the safe region. Instead of using the onboard dynamic load circuit, an electric load can also be used for the load step test, which does not have the 2% max duty cycle limit for the load step.

The EXTVCC pin is connected by default to VOUT, through the R3 jumper. Remove the R3 jumper before applying external voltage to the EXTVCC pin.

Because of the internal controller in the LTM4654 module, it is normal to see increased switching frequency after long-time running, as higher temperature leads to higher switching frequency.

Typical Performance Characteristics

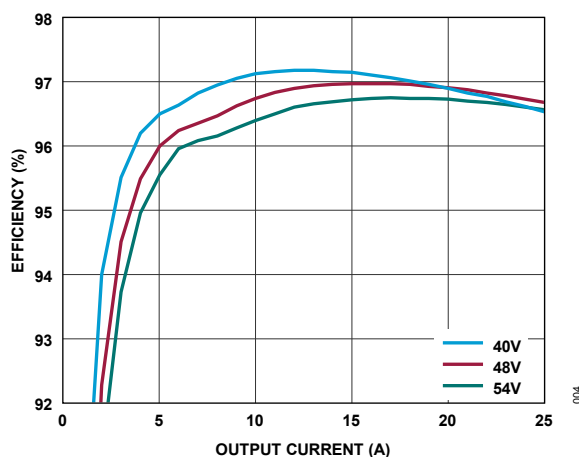


Figure 4. Efficiency vs. Load Current at $V_{OUT} = 12V$

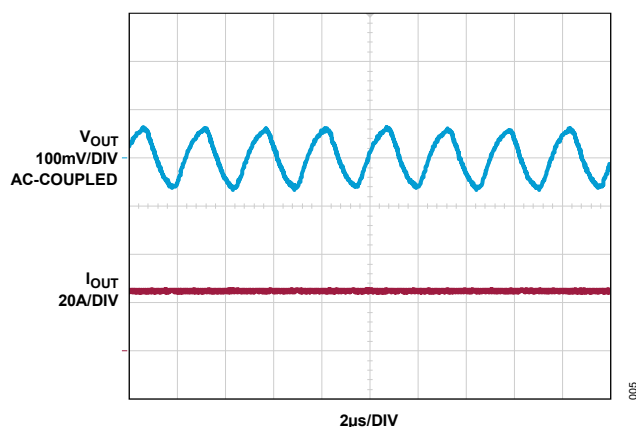


Figure 5. Output Voltage Ripple at $V_{IN} = 48V$, $V_{OUT} = 12V$, $I_{OUT} = 25A$, V_{OUT} Peak-to-Peak = 134mV

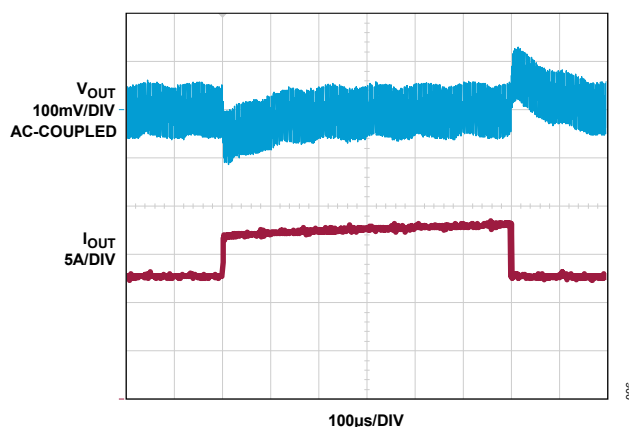


Figure 6. Load Step at $V_{IN} = 48V$, $V_{OUT} = 12V$, $I_{OUT} = 12.5A$ to $18.75A$, V_{OUT} Peak-to-Peak = 248mV

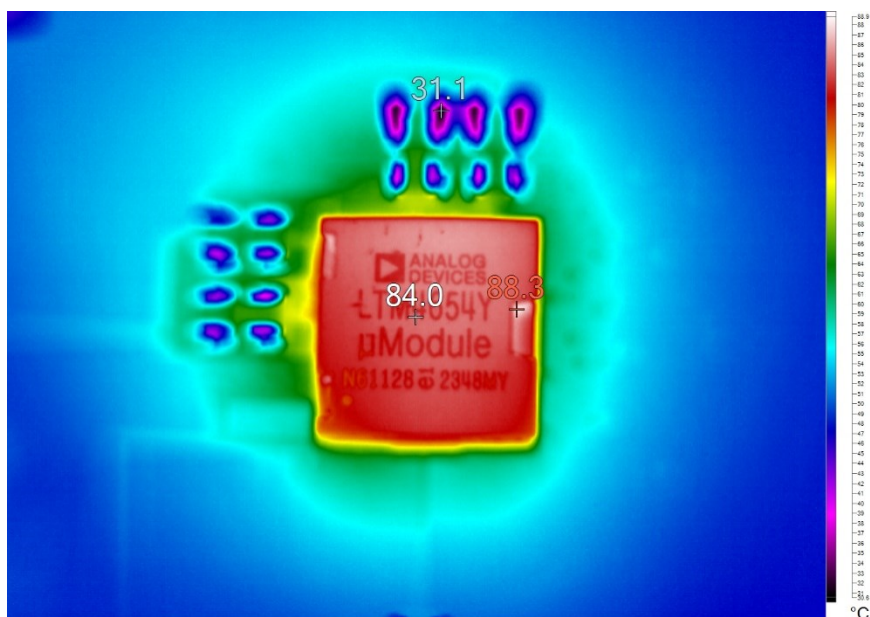


Figure 7. Thermal Performance $V_{IN} = 48V$, $V_{OUT} = 12V$, $I_{OUT} = 25A$, $T_A = 23^{\circ}C$, No Heatsink, No Airflow

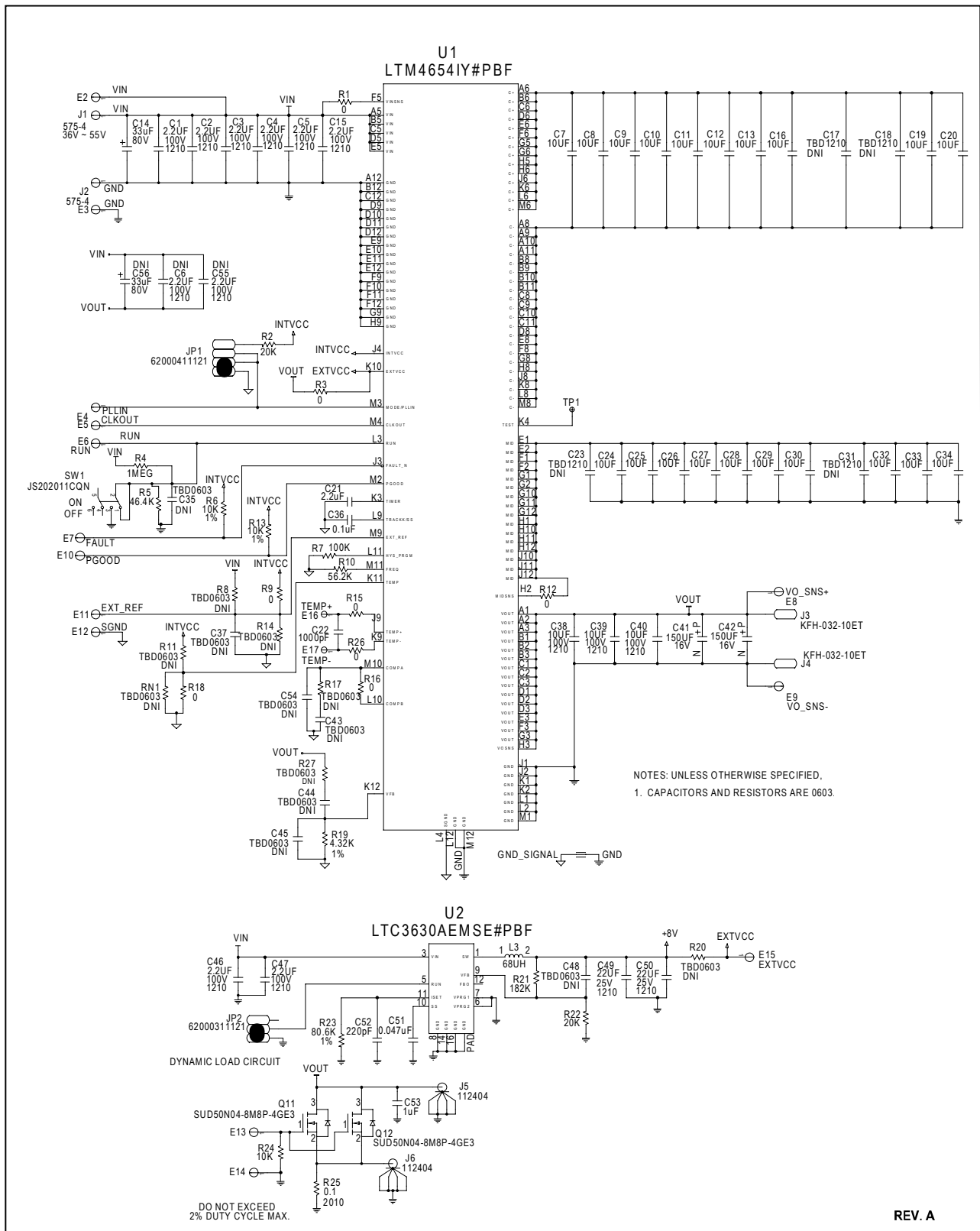
EVAL-LTM4654-AZ Evaluation Board Bill of Materials

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
REQUIRED CIRCUIT COMPONENTS				
1	8	C1 to C5, C15, C46, C47	CAPACITOR CERAMIC 2.2 μ F 100V 10% X7R 1210	KEMET C1210X225K1RAC7800, AVX 12101C225KAT2A
2	23	C7 to C13, C16, C19, C20, C24 to C30, C32 to C34, C38 to C40	CAPACITOR CERAMIC 10 μ F 100V 10% X7S 1210	MURATA GRM32EC72A106KE05L
3	1	C14	CAPACITOR ALUM POLY HYBRID 33 μ F 80V 20% 10mm $\times$ 10.2mm AEC-Q200	PANASONIC EEHZA1K330P
4	1	C21	CAPACITOR CERAMIC 2.2 μ F 25V 10% X7S 0603	MURATA GRM188C71E225KE11D
5	1	C22	CAPACITOR CERAMIC 1000pF 50V 10% X7R 0603	YAGEO CC0603KRX7R9BB102
6	1	C36	CAPACITOR CERAMIC 0.1 μ F 25V 10% X7R 0603	SAMSUNG CL10B104KA8NNNC
7	2	C41, C42	CAPACITOR CERAMIC POLY 150 μ F 16V 20% (8mm $\times$ 6.9mm) 0.022 Ω 3220mA 2000H	PANASONIC 16SVPC150M

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
8	2	C49, C50	CAPACITOR CERAMIC 22 μ F 25V 20% X5R 1206	TDK, C3216X5R1E226M160AB
9	1	C51	CAPACITOR CERAMIC 0.047 μ F 25V 5% X7R 0603	AVX 06033C473JAT2A KEMET C0603C473J3RACTU
10	1	C52	CAPACITOR CERAMIC 220pF 50V 5% C0G 0603 LOW ESR	TDK C1608C0G1H221J080AA
11	1	C53	CAPACITOR CERAMIC 1 μ F 25V 10% X7R 0603 AEC-Q200	MURATA GCM188R71E105KA64D
12	1	L3	INDUSTRIAL POWER SHIELDED 68 μ H 20% 1.35A 0.25 Ω DCR AUTOMOTIVE	COILCRAFT INC. MSS7341-683MLB COILCRAFT INC. MSS7341-683MLD
13	2	Q11, Q12	TRANSISTOR N-CHANNEL MOSFET 40V 14A	VISHAY SUD50N04-8M8P-4GE3
14	8	R1, R3, R9, R12, R15, R16, R18, R26	RESISTOR SMD 0 Ω JUMPER 1/10W 0603 AEC-Q200 PRECISION POWER	VISHAY CRCW06030000Z0EA
15	1	R10	RESISTOR SMD 56.2k Ω 1% 1/10W 0603	YAGEO RC0603FR-0756K2L
16	3	R6, R13, R24	RESISTOR SMD 10k Ω 1/10W 1% 0603 AEC-Q200	VISHAY CRCW060310K0FKEA
17	1	R19	RESISTOR SMD 4.32k Ω 1% 1/10W 0603 AEC-Q200	PANASONIC ERJ-3EKF4321V
18	2	R2, R22	RESISTOR SMD 20k Ω 1% 1/10W 0603 AEC-Q200	PANASONIC ERJ-3EKF2002V
19	1	R21	RESISTOR SMD 182k Ω 0.1% 1/10W 0603 AEC-Q200 HIGH RELIABILITY	PANASONIC ERA-3AEB1823V
20	1	R23	RESISTOR SMD 80.6k Ω 1% 1/10W 0603 AEC-Q200	VISHAY CRCW060380K6FKEA
21	1	R25	RESISTOR SMD 0.1 Ω 1% 1W 2010 AEC-Q200	VISHAY WSL2010R1000FEA18
22	1	R4	RESISTOR SMD 1M Ω 1% 1/10W 0603 AEC-Q200	PANASONIC ERJ-3EKF1004V
23	1	R5	RESISTOR SMD 46.4k Ω 0.1% 1/10W 0603 AEC-Q200 HIGH RELIABILITY	PANASONIC ERA-3AEB4642V
24	1	R7	RESISTOR SMD 100k Ω 1% 1/10W 0603 AEC-Q200	VISHAY CRCW0603100KFKEA
25	1	U1	IC-ADI 55V, 300W SOURCE/SINK HYBRID STEP-DOWN NON-ISOLATED μ Module BUS CONVERTER	ANALOG DEVICES LTM4654IY#PBF
26	1	U2	IC-ADI STEP-DOWN DC-TO-DC CONVERTER SYNCHRONOUS 76V 0.5A AUTOMOTIVE 16LD MSOP	ANALOG DEVICES LTC3630AEMSE#PBF

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
ADDITIONAL EVALUATION BOARD CIRCUIT COMPONENTS				
1	0	C17, C18, C23, C31	CAPACITOR, OPTION, 1210	
2	0	C35, C37, C43 to C45, C48, C54	CAPACITOR, OPTION, 0603	
3	0	C6, C55	CAPACITOR, DO NOT INSTALL, 1210	
4	0	C56	CAPACITOR, DO NOT INSTALL, ALUM POLY HYBRID 10mm ×10.2mm	
5	0	R8, R11, R14, R17, R20, R27, RN1	RES., DO NOT INSTALL, 0603	
HARDWARE: FOR EVALUATION BOARD ONLY				
1	16	E2 to E17	CONN-PCB SOLDER TERMINAL TEST POINT TURRET 0.094-INCH MTG. HOLE PCB 0.062-INCH THK	MILL-MAX 2501-2-00-80-00-00-07-0
2	2	J1, J2	CONN-PCB, BANANA JACK, FEMALE, NON-INSULATED, THT, SWAGE, 0.218-INCH LENGTH	KEYSTONE ELECTRONICS 575-4
3	2	J3, J4	CONN-PCB THREADED BROACHING STUD, 625Mil LENGTH	PENN ENGINEERING KFH-032-10ET
4	2	J5, J6	CONN-PCB BNC JACK ST 50Ω	AMPHENOL CONNEX 112404
5	1	JP1	CONN-PCB HDR ST 4-POS, 2mm PITCH, 4mm POST HEIGHT, 2.7mm SOLDER TAIL LENGTH	WÜRTH ELEKTRONIK 62000411121
6	1	JP2	CONN-PCB 3-POS MALE HDR UNSHROUDED SINGLE ROW ST, 2mm PITCH, 2.70mm SOLDER TAIL	WÜRTH ELEKTRONIK, 62000311121
7	1	SW1	SWITCH SLIDE DPDT 300mA 6V	C&K, JS202011CQN

EVAL-LTM4654-AZ Evaluation Board Schematic



Ordering Information

PART NUMBER	DESCRIPTION
EVAL-LTM4654-AZ	55V, 300W Step-Down μ Module Regulator evaluation (demo) board.

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	10/2025	Initial release	—

Notes

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